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Canada: Geodetic Service

DEPARTMENT OF THE INTERIOR, CANADA

HON. THOMAS G. MURPHY, Minister — H. H. ROWATT, Deputy Minister

GEODETIC SURVEY OF CANADA

NOEL J. OGILVIE, Director

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ANNUAL REPORT

OF THE DIRECTOR

OF THE

GEODETIC SURVEY OF CANADA

FOR THE

FISCAL YEAR ENDING MARCH 31, 1931

1930/31

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1932

OPERATIONS OF THE GEODETIC SURVEY OF CANADA

Top—Geodetic Survey Building at Ottawa.

Second row, left to right—
- North end of Standard building, showing five-meter bar apparatus.
- Office of Precise Level Adjusting Division.
- Fiducial point at south end of 50-meter comparator, in Standard building.

Third row, left to right—
- Precise Level, U.S.C. & G.S. Pattern.
- Latest Model Primary Triangulation Model theodolite.
- Latest Model Astronomical Transit.
- Electric Signal Lamp for Primary Triangulation.
- Precise Level, Zeiss Model.

Bottom row, left to right—
- Observing on Secondary Triangulation.
- Photographic and Transport Hydroplane, Canadian model.
- Sending instructions to light keepers by heliograph.
- Setting rear end of tape in Baseline measurement.
- Observing Precise Levels in the Yukon Territory.
- A Transport Hydroplane at rest.
- Observing Primary Triangulation.

On flanks—
- Triangulation Tower near Chatham, Ont., with Lamp-stand extended 37 feet. Height of Lamp-stand: 147 feet.

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THE GEODETIC SURVEY OF CANADA

ANNUAL REPORT OF THE DIRECTOR, NOEL J. OGILVIE

INTRODUCTION

The operations of the Geodetic Survey of Canada, Department of the Interior, during the fiscal year ended March 31, 1931, comprised geodetic triangulation, precise traverse, precise and secondary levelling, geodetic astronomy, base line measurement, isostasy, geodetic research, triangulation adjustment, precise levelling adjustment, testing new types of geodetic instruments and the publication of geodetic survey data.

Field parties carried on geodetic operations in the provinces of British Columbia, Saskatchewan, Ontario, and Quebec.

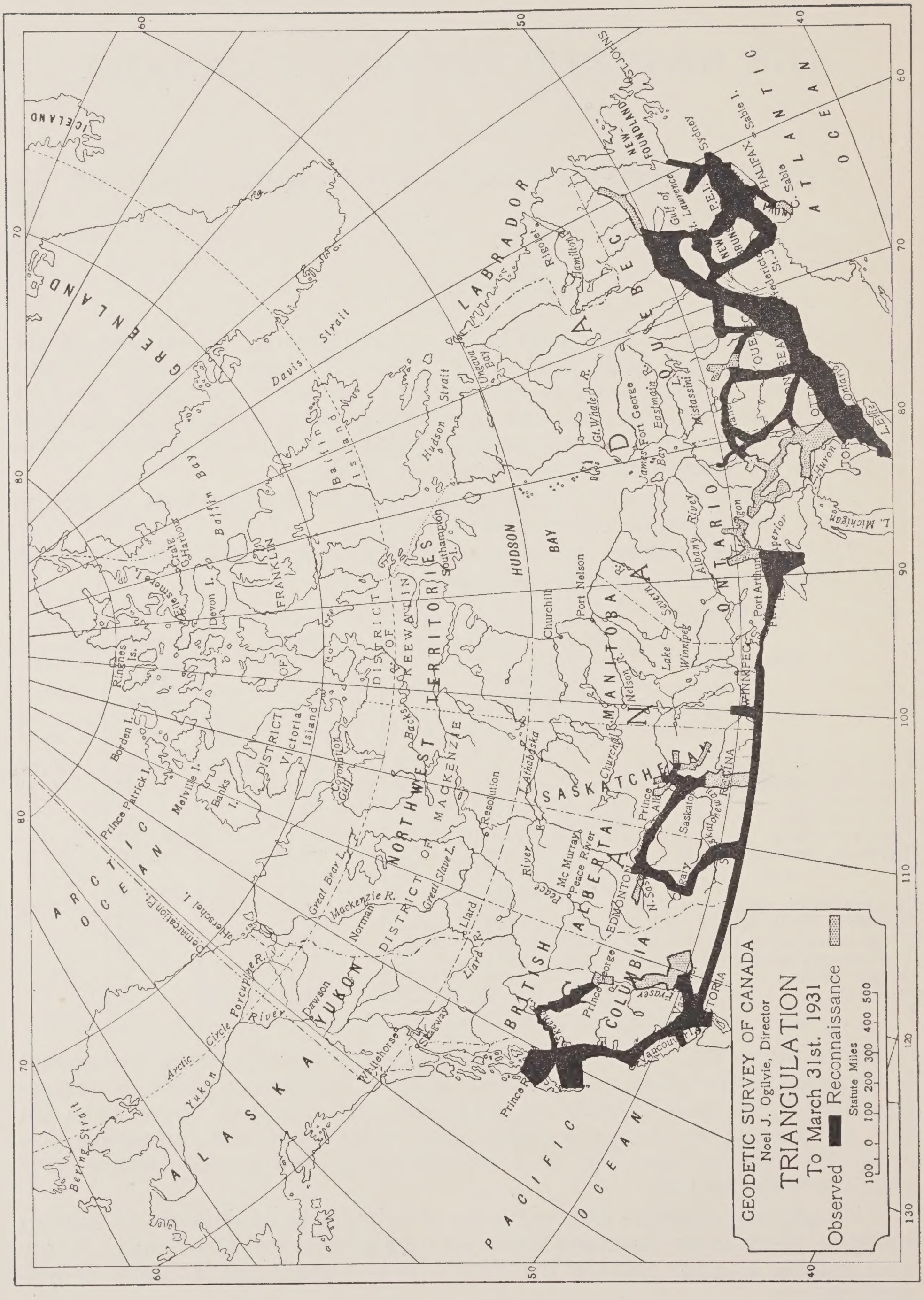
The following tabular statement shows the work of the seasons 1929-30 and 1930-31 as well as the total accomplished to date:—

Field Operations	1929–30		1930–31		Total to Date	
	Axial length	Area	Axial length	Area	Axial length	Area
	miles	sq. miles	miles	sq. miles	miles	sq. miles
Primary triangulation	628	12,857	422	10,510	7,205	197,842
Secondary triangulation	99	1,345	....	....	973	5,605
Reconnaissance	538	13,723	1,430	28,611	....	
Precise traverse	13	....	83	....	505	
Precise levelling	451	....	189	....	24,463	
Secondary levelling	425	....	680	....	10,938	
	Number		Number		Number	
Standard bench marks	224	....	118	....	8,544	
Secondary bench marks	162	....	388	....	3,716	
Fundamental bench marks	19	....	24	....	110	
Geodetic astronomic stations	14	....	11	....	57	
Laplace stations	3	....	3	....	52	
Base lines	2	....	1	....	29	

This Survey has received requests from federal and provincial government departments, municipalities, corporations and the engineering public in increasing numbers for geodetic latitudes, longitudes and elevations above mean sea level for the purpose of precise control data in surveying and engineering projects. On every occasion the most recently determined geodetic results have been promptly forwarded.

The geodetic latitudes and longitudes of points with descriptions of stations in certain areas in the Maritime Provinces were printed and distributed. Those for a number of other areas in the same part of Canada are in course of preparation.

The results of precise levelling in Vancouver island were prepared for publication.


GEODETIC SURVEY OF CANADA
Noel J. Ogilvie, Director
TRIANGULATION
To March 31st. 1931
Observed
Reconnaissance
Statute Miles
100 0 100 200 300 400 500
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
GREENLAND
ICELAND
ALASKA
YUKON
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
LABRADOR
NEWFOUNDLAND
NORTHWEST TERRITORIES
DISTRICT OF MACKENZIE
DISTRICT OF KEEWATIN
DISTRICT OF FRANKLIN
HUDSON BAY
Hudson Strait
Davis Strait
Baffin Bay
Baffin Island
Victoria Island
Banks I.
Melville I.
Prince Patrick I.
Borden I.
Ringnes Is.
Devon I.
Southampton I.
Ungava Bay
James Bay
Bering Strait
Arctic Circle
Yukon
Porcupine R.
Herschel I.
Demarcation Pt.
Dawson
Whitehorse
Skagway
Great Bear L.
Great Slave L.
Mackenzie R.
Norman
Liard R.
Resolution
L. Athabaska
Peace River
Mc Murray
EDMONTON
Prince George
Prince Albert
REGINA
WINNIPEG
Lake Winnipeg
Churchill
Port Nelson
Nelson R.
Severn R.
Albany River
Port Arthur
Superior
L. Michigan
L. Huron
L. Erie
Ontario
TORONTO
OTTAWA
MONTREAL
QUEBEC
L. Mistassini
Eastmain R.
Fort George
Gt. Whale R.
Hamilton
Gulf of St. Lawrence
NEW BRUNSWICK
P.E.I.
HALIFAX
Sydney
Sable I.
ST. JOHNS
VICTORIA
Vancouver I.
Prince Rupert
Fraser
Coronation Gulf
Backs R.

The material prepared by the Geodetic Survey of Canada on the occasion of the Fourth General Conference of the International Geodetic and Geophysical Union at Stockholm, Sweden, was printed and distributed.

Further progress is reported in the development of special methods for the accurate control of long geodetic lines, a practical application of which was made in the delineation of the Manitoba-Ontario Boundary line.

The precise traverse has again proved a valuable substitute for triangulation of level terrains with heavy standing timber. Special investigation as to the conformation of the precise traverse to the curvature of the earth's surface was taken into consideration.

Aeroplane transportation was again found economical in the field operations of the Geodetic Survey of Canada, and the aeroplanes required were provided through co-operation with the Royal Canadian Air Force.

Seven publications of the Geodetic Survey of Canada were printed and distributed by means of an annually revised mailing list.

TRIANGULATION

The season of 1930 was only partially favourable for triangulation. In the various localities occupied, rain and fog in the spring or smoke from forest fires in the summer and fall produced one of the worst seasons on record so far as the progress of angular measurements was concerned. On the other hand the use of pontoon-equipped aeroplanes as a transportation unit enabled reconnaissance parties to double the usual mileage of triangulation laid out ready for completion.

The progress of the field work in triangulation and precise traverse during 1930 is indicated on page 8. One thousand and fifty-two miles (18,556 square miles) of aerial reconnaissance which has not been checked on the ground is included.

Comparative field tests of angular measurements between the new and older types of instrument showed a very satisfactory agreement, and the precision of the 1930 angular measurements with the Wild type of instrument fulfilled the rigid standards laid down for primary triangulation.

RECONNAISSANCE BY AEROPLANE

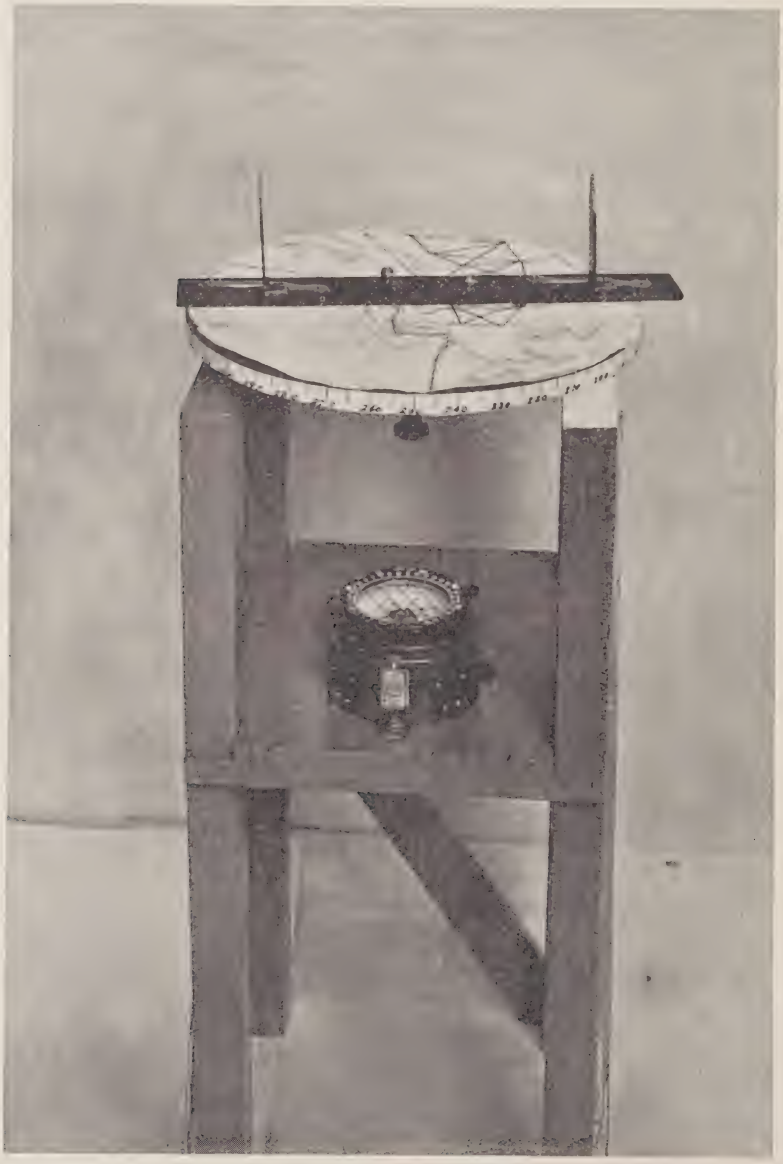
In Canadian geodetic practice since February, 1929, the aeroplane has become an increasingly efficient instrument for triangulation reconnaissance.* During 1930 additional experience was gained in the technique required for taking the fullest advantage of this speedy mode of selecting sites for triangulation stations.

From January to April, 1931, much experience was gained and the following work was completed by aeroplane. A triangulation net 720 miles long in northern Ontario and one in Saskatchewan 185 miles long were laid down, while 20 stations were selected in various parts of Manitoba. Topographic conditions were encountered in which hills varied from 500 feet to less than 100 feet above the waterways. Owing to the absence of water areas in one district it was decided that an aerial reconnaissance of it could not be made in safety. Figures were obtained which give a fair basis on which progress and cost may be estimated. Stereoscopic oblique photography has been further tried as an aid in testing the intervisibility of stations and some interim conclusions may be drawn from these tests.

*See Annual Report of the Director, Geodetic Survey of Canada, 1929, p. 8.

Practically no new technical methods have been developed for carrying on the reconnaissance. The modified plane table developed in 1929, illustrated on this page is still used in its original form. With added experience this instrument has become increasingly efficient even to the extent of laying down triangulation nets over entirely unmapped areas.

Increased experience has naturally added considerably to the speed with which the reconnaissance is carried on—largely due to a greater amount of necessary information being obtained in the first flights over an area and the need of fewer subsequent flights to supplement initially obtained data. In this connection the vital difference between aeroplane and ground reconnaissance must be appreciated. In the latter plenty of time is usually available while the



Apparatus used in Aerial Reconnaissance.

engineer is on a hill to digest the data obtained, to revise tentative plans and make new ones, and to obtain further information if new plans require it. In the aeroplane reconnaissance minutes rather than hours are available for securing a maximum of data, making these data fit into a triangulation net and making plans for further flying. Under these circumstances it is understandable that second or even third flights may be needed to determine whether or not certain lines unobserved on a first flight are open. At the start the engineer's mind is in a whirl trying to work at such speed, and when a pilot asks, "Where shall we go next?", he is apt to wish for half an hour to sit down and consider all the data before making further plans. Gradually that feeling passes, fuller information is obtained, decisions are made as to what further flying, if any, is required at a site and as to what the next plans for flying are to be.

In northern Ontario the country covered was quite rugged with many lakes, except for one area, and the reconnaissance was comparatively easy. In northern Saskatchewan, however, the net had to cross a flat, swampy area in which the height of the hills was frequently less than 100 feet above the water areas. Flying as low as the tops of the hills in such country, even over water areas, in single-motor planes is considered sufficiently hazardous to mark a limit to the use of aeroplanes for reconnaissance. This area, as well as the flat Manitoba country in which reconnaissance was carried on, gave a very severe test of the possibility of doing satisfactory reconnaissance from an aeroplane. Methods used in more rugged country for testing the intervisibility of stations were not as a rule feasible, and experience in laying down triangulation in similar country provided the only means of judging the possible length of line and the probability of the stations being intervisible. On account of the low relief it was too hazardous to attempt the low flying—even over water areas—which would be necessary to actually sight from one selected site to others.

This reconnaissance in flat country will require ground checking before judgment can be passed on its success.

In one small area of northern Ontario across which it was necessary to select a net, there were no lakes or other emergency landing places, so that the necessary low flying could not be done in the single-motor planes used on the work.

As a result of operations in northern Ontario and Saskatchewan the following data are available on which future progress and cost may be estimated:—

—	720-mile nets in Northern Ontario	185-mile nets in Saskatchewan
Axial distance along net per flying hour	11 miles	12 miles
Area covered per flying hour	223 sq. m.	218 sq. m.
Stations selected per flying hour	1·7	1·2

The flying time going to and returning from the reconnaissance area has not been included in arriving at the above figures, as this would naturally vary with the distance of the area from the permanent aeroplane base. Extra engine time on the ground is not included, as it varies with the season of the year, being neglible in summer but appreciable in winter. In any estimates of fuel consumption for laying down of supplies, or for estimate of cost, these items should be added to figures calculated from the above table.

Further experiments were carried out with stereoscopic oblique photography to see if methods could be developed to make it a worth while adjunct to aeroplane reconnaissance. To date its value at the recorded cost is questionable. As a supplement to the description of the stations and the method of approach the photographs are very valuable. Where the lines between hills lie well above intervening country the photographs show this condition very clearly. But where a line lies close to the ground or is blocked by a few feet of intervening

timber or a hill, the methods employed at present are not sufficiently decisive to be worth the cost, which to date has been almost as great as the aeroplane reconnaissance without photography. The photographs were taken with a 20-inch lens and a minus blue filter. Further experiments will no doubt be made to determine whether or not these and other disadvantages in the present methods can be overcome.

The conclusion to be drawn from aeroplane reconnaissance to date is that in districts where transportation is very slow it is decidedly economical even if ground checking of the air work is found necessary. Apart from the economy the use of aeroplanes as a means of transport for laying out a system of triangulaton over large areas of Canada years in advance of final operations has

Eighty-foot Steel Tower; Forest Service Type with Geodetic Survey Tripod ready for use in Triangulation Operations.

other advantages. In parts of the country such as northern Ontario where a program of building steel lookout towers for fire detection is in progress, the triangulation stations offer a valuable choice of hills as sites for these towers. The towers when built with trails and telephone lines installed are of great assistance when the triangulation is being completed. It is therefore mutually advantageous to forestry and geodetic survey officials to have the triangulation laid out well in advance of subsequent operations. When the preliminary work of the triangulation has been laid out well ahead of subsequent operations, as is possible when it is done by aeroplane, there need be no delay in completing the final work in any outlying area as soon as development takes place or maps are required. In this way results can be made available on an astronomical

datum well in advance of the date of their employment. When the preliminary work has to be done by ground travel in rough country it is sometimes two years or more before results are available to those requiring the information. With aeroplanes as a means of transport in laying out the triangulation a year or more is gained in delivering results. Another advantage is that, the triangulation having been laid out with its different grades of accuracy as needed, operations which are required in isolated sections can be completed with the grade of accuracy which will make them fit in with the final net as laid out for the whole country.

Primary Triangulation in Southern British Columbia

Results Obtained.—*Reconnaissance:* 16 primary and 3 secondary stations selected; axial length of net, 134 miles; area covered, 3,825 square miles. *Station Preparation:* 16 stations prepared. *Angular Measurements:* 7 primary stations completed; axial length of net; 110 miles; area covered, 32,050 square miles.

Triangulation operations in British Columbia were a continuation of a triangulation and traverse loop in the interior of the province. The western and northern sides of this loop, lying along the coast from Vancouver to Prince Rupert, and along the Canadian National railway from Prince Rupert to Prince George respectively, are completed. Work on the southern and eastern sides of this loop, from Vancouver to Prince George via the Fraser River valley, was commenced in 1929 at Vancouver.

The angular measurements were commenced during the latter part of May on stations in the Cascade range about 100 miles east of Vancouver. Owing to continual rain and cloudiness on these mountains, observations were delayed until the end of June. During July conditions were more favourable for angular measurements but forest fires started in August, and the air was filled with smoke. Altogether the season was a very unfavourable one for angular measurements.

Reconnaissance for the selection of stations was carried on east of the Cascade mountains where the climate was drier and the season more advanced, and very fair progress was made. Points selected and marked by other surveys were occupied wherever possible, but where this was not the case a traverse survey was made from the Geodetic station to the point so established.

Station preparation parties followed closely behind the reconnaissance. Generally the mountains were bare on top and trails were already made in the case of those stations established by other surveys; the mountain tops at some new stations were heavily timbered and considerable work was necessary to clear the lines of site to other stations. Trails were made where necessary and observing tripods and lampstands built.

At Salmon Arm the base line of the Railway Belt triangulation was recovered and an expansion from it to the geodetic triangulation net was selected. This base line had been measured with a very high precision thus rendering it quite suitable for a primary triangulation base line without re-measurement. The recovery of the base line monuments presented some difficulty. The marks were three feet underground and surface marks as well as the land survey posts to which connections were made when the base line was measured had disappeared. After digging unsuccessfully at points indicated by information supplied by local authorities who had seen the monuments put in, the land lines were re-run, approximate positions of the nearest corners established and the positions of the ends of the base line determined from the original connections. A little sounding with a four foot iron bar located the concrete monuments, and the tablets were uncovered and found to be in good condition.

Valuable assistance was freely given by officers of the Forest Service, Department of the Interior in respect to information about the trails and the use of their cabins and lookout towers was given whenever required.

Primary Triangulation in Saskatchewan

Results Obtained.—*Reconnaissance* (Engineer and Assistant): 58 stations selected; axial length of net 214 miles; area covered, 2,383 square miles. *Aerial Reconnaissance* (Engineer and Pilot): 19 stations selected; axial length of net, 185 miles; area covered, 2,380 square miles. *Station Preparation* (Foreman and 5 men): 29 standard piers built, (with 3 supplementary bolts); 8 towers built, (total height 300 feet); distance covered, 300 miles. *Angular Measurements*: (Engineer and 6 men): 34 primary stations and 1 supplementary station completed; axial length of net, 170 miles; area covered, 3,222 square miles; 12 connections with land survey corners.

Triangulation during the fiscal year 1930-31 was chiefly in the development of the main control system planned for midwestern Canada. In the previous years a large loop had been laid down running north from the International Boundary scheme south of Medicine Hat through Calgary to Edmonton, thence east to the vicinity of Prince Albert, thence south through Saskatoon and Regina to again join the International Boundary net. Station preparation and angular measurements during 1930 were confined to this loop while reconnaissance was begun on another loop further to the east and on an extension of the triangulation northward from Prince Albert to Big River as the first step in a triangulattion system to the promising mineral areas in the north country. As Big River is the northern limit of automobile transportation and neither canoe nor aeroplane transport was immediately available the reconnaissance unit moved east to Melfort.

From Melfort a net was commenced in the southeast direction, the objective being Brandon, Man., where a short net had been already laid down to connect with the International Boundary net. Reconnaissance on this chain was completed as far as Canora, Sask., where the operation was discontinued at the close of the season.

The type of country encountered between Melfort and Canora entails a large expenditure for tower building. The average length of line was short—about 9 miles—so that the number of stations was large and towers of an average height of 45 feet were required at all but two of them. It was evident that nothing could be gained by making the lines longer at the expense of higher towers. It was decided to investigate alternative routes before the completion of this net is undertaken.

In view of the likelihood of triangulation being extended at an early date into northern Canada via the Prince Albert-Big River net mentioned above, it was deemed advisable to extend the reconnaissance further to the north before observations were commenced. Accordingly in March, 1931, an engineer undertook this reconnaissance from a ski-equipped aeroplane.

It proved advisable to continue the Big River net to the north on account of the very flat country traversed, but it was found that the net from Prince Albert north through Prince Albert National Park could be substituted for the former net. This was extended north 120 miles to the vicinity of lac la Ronge, with branches 65 miles in length.

The preparation of stations during 1930 was carried out satisfactorily as given in the summary of results obtained.

Angular measurements were started at Red Deer Hill near Prince Albert and carried easterly as far as the base line near Beatty, Saskatchewan. The party was then moved to station Hague, 50 miles south of Prince Albert and worked southerly through Saskatoon towards the international boundary. At the close of the season operations had reached a point about 50 miles north of Moose Jaw without completing this net.

Control was supplied for the city of Saskatoon by fixing the position of a copper bolt on top of the tower of Robin Hood flour mill, and observations were taken to make available to the University of Saskatchewan, the geodetic position of a pier in the new observatory.

The progress of the angular measurement parties was satisfactory, taking into consideration weather conditions and lateral refraction difficulties. Visibility

was very poor during the first half of June due to smoke and during the second half due to rain. In the month of July, however, the weather was exceptionally favourable for obtaining good results. Days in general were very hot and the nights fairly cool. During August and September, however, haze and lateral refraction seriously retarded the angular measurements, as shown by the fact that 19 stations were completed in July, while only 9 stations were completed during August and the first half of September.

The conditions which produce horizontal refraction are many and varied, so that it seems that its occurrence is accidental, but the examination of extensive data secured in the Prairie Provinces in the last six years, may indicate some outstanding factors which result in this phenomenon and which will lead to the daily recording of certain data in the field notes.

Primary Triangulation and Precise Traverse in Northern Ontario

Results Obtained.—Triangulation.—*Reconnaissance*: 17 primary and 10 secondary stations selected; axial length of net, 150 miles; area covered, 4,630 square miles. *Revision of Former Reconnaissance*: 4,000 square miles. *Aerial Reconnaissance*: 94 primary and 17 secondary stations selected; axial length of net, 720 miles; area covered, 14,290 square miles. *Station Preparation*: 11 stations were prepared at 4 of which towers were erected. *Angular Measurements*: 8 primary stations and 1 primary station occupied; 30 intersection stations observed on; 4 lot corners connected to triangulation stations; axial length of net, 40 miles; area covered, 1,433 square miles.

Precise Traverse. *Station Preparation*: 11 azimuth stations prepared at 8 of which towers were erected. *Augular Measurements*: 11 azimuth stations and 103 traverse stations completed over a distance of 63 miles. *Traverse Measured*: 83 miles.

The operations of the parties in northern Ontario were carried on in three sections of the country: along the James Bay extension of the Temiskaming and Northern Ontario railway; from Sudbury westward towards Sault Ste. Marie; and from Sudbury northwest to the northwest end of lake Nipigon.

At the commencement of the season a precise traverse along the James Bay extension of the Temiskaming and Northern Ontario railway was continued from Mile 16 north of Cochrane northward to Mile 99 north of Cochrane in the vicinity of Coral Rapids, where the operation was discontinued for the season. From this point north the railway line was under construction. This district is a difficult one for traverse as the railway crosses timber-covered muskeg with a few clay knolls. High towers were required on most of the azimuth stations and considerable difficulty was encountered in setting permanent station monuments.

An examination of the country indicated that a few high towers a considerable distance apart would be more economical than a larger number of low ones with short lines. The traverse therefore consisted of a comparatively small number of so called azimuth stations joined by lines of an average length of eight miles which followed only approximately the railway line. Between these azimuth stations, a number of points, called traverse stations, were placed along the railway right of way. The linear measurements were made between the traverse stations and consisted of one measurement with a 50-metre invar tape and one check measurement with a 300-foot steel tape to detect gross errors in the invar taping.

The taping commenced on June 4 at Mile 16 north from Cochrane and was discontinued August 6. The curved nature of the railway track in certain places and the boggy ground necessitated extra care in all phases of the operation.

Angular measurements at both azimuth and traverse stations were carried on at the same time as the taping.

Reconnaissance for the triangulation operations commenced on June 6 in the Sudbury area where a base line was chosen to fit into the primary net. The Blezard valley provided a very suitable location and the line chosen has an approximate length of six and a half miles. The ends are stationed on com-

paratively low hills while the line crosses farms or rather unbroken ground where only a limited amount of preparatory work is necessary prior to undertaking measurement operations.

On the completion of the selection of the base net the reconnaissance party moved westward to Manitoulin island where primary and secondary stations were chosen on outstanding points near the north shore of the island to give a good general control of the water areas lying to the north and east in particular, and the whole of Manitoulin island in general. Later, corresponding points were selected on the mainland to the north of the island. A sufficient number of secondary points were also selected north of the main net to give control of the mainland for a distance of 30 miles north from the north shore of Georgian bay as far west as Sault Ste. Marie. In addition the reconnaissance along Georgian bay as far as its southern end was checked and revised where necessary Field operations on the reconnaissance closed on October 12.

On the completion of the precise traverse reported on above the tower building party moved to the Sudbury area where station preparation was continued westerly and southerly. Work was stopped early in October on Manitoulin island.

Angular measurements were carried on from August 11 to the end of September westerly and southerly from the Sudbury district.

In general throughout the field season of 1930 weather conditions were fair. There was considerable rain in the early part of the season, but after the 1st of July precipitation appeared to fall below normal. Very little time was lost due to haze or smoke from bush fires, but smoke from the smelters at Copper Cliff and Coniston produced some interference.

During four weeks of January and February, 1931, an aerial reconnaissance for a triangulation net was made from the completed triangulation at Sudbury northwest as far as the northwest end of lake Nipigon. The first part of this net parallels the Canadian Pacific railway as far as Franz then strikes north of this railway toward the southern end of lake Nipigon; thence it proceeds to the north and northwest angles of lake Nipigon. Branches from this main net were laid down from Woman river towards Timmins connecting with completed work in that area. Another branch runs south from Franz along the Algoma Central railway to within 30 miles of Sault Ste. Marie at which point it will join the ground reconnaissance reported on above. A third short branch extends north from Long Lac to Nakina on the northerly line of the Canadian National railway, while a fourth branch was laid down southerly along Nipigon river to join the completed triangulation in the Porth Arthur area.

Primary Triangulation in Western Quebec

Two groups of parties operated in western Quebec during the season of 1930, both being engaged on the triangulation chain which roughly follows the transcontinental line of the Canadian National railway and the net which runs north from Ottawa to intersect this scheme. Reconnaissance was carried on for the extension of the triangulation system in a northwesterly direction from the transcontinental line near the village of Oskelaneo.

One of the these groups of parties commenced operations at the westerly boundary of the province near La Reine, Que., and on the completion of this work moved to the easterly end of the same net near Windigo, Que., to work westward until the end of the season.

Results Obtained.—*Reconnaissance:* 1 station selected. *Station Preparation:* 1 ground station prepared for angular measurment. *Angular Measurements:* 7 primary stations completed; axial length of triangulation, 48 miles; area covered by triangulation, 770 square miles.

Operations were begun the last week in May. While the personnel was being trained in signalling and the use of automatic signal lamps, a reconnaissance was made to select the points required to strengthen the net in the vicinity of La Reine. It was found possible to do this by the addition of one station.

The second group of parties worked northward from a point roughly 75 miles north of Maniwaki, P.Q. By the end of the season they had reached the Transcontinental line of the Canadian National railway and were working eastward to connect this work with the Senneterre net.

Results Obtained.—*Reconnaissance:* 9 stations selected by areoplane, 7 stations of previous aerial reconnaissance ground checked; axial length of new reconnaissance, 47 miles; area covered, 887 square miles. *Station Preparation:* 22 primary and 7 secondary stations prepared at 18 of which towers or tripods were built. *Angular measurements:* 9 primary and 4 secondary stations completed; axial length of net, 75 miles; area covered 2,130 square miles.

This group of parties depended for transportation largely on two Fairchild 71B aeroplanes with an air base at lake Menjobagues a short distance to the east of the triangulation area. Owing to a variety of circumstances, mainly weather conditions and an accident to one of the aeroplanes, considerable delays were occasioned and the progress of these parties was not as good as had been anticipated. These aeroplanes formed a detachment equipped for aerial photography but owing to the same inclement weather which delayed triangulation operations a rather disappointing photographic season was experienced.

From June 2 to October 7 the reconnaissance party was employed making traverse connections from three triangulation stations to the line defining the southerly limit of Abitibi county, together with the establishment of one secondary station and the necessary observations for its position. On the conclusion of this work the party ground checked aerial reconnaissance laid out the previous winter and near the end of the season carried on the aerial reconnaissance for triangulation in a northwesterly direction from Oskelaneo towards lake Waswanipi.

Two station preparation parties were engaged in this district. One of them prepared stations which were not accessible by aeroplane, while the other was dependent on the planes for transportation and supplies.

Two angular measurement parties operated during the season.

The total number of flying hours chargeable to this operation was 74 and the total number of rolls exposed was 40. Low altitude photographs were taken of all geodetic stations for identification purposes, also flights were made between a number of triangulation stations for examination of the country. During July and August four observing parties (two from each group of parties), two lightkeeping parties and one tower building party were dependent on two planes for their transportation. These parties were scattered a distance of approximately 160 miles and it was a general rule that difficult or impossible flying conditions were of frequent occurrence over some part of this area. The work of transportation for this number of parties over such a large district was really too great for two planes and this contributed to the delays in the movements of the two parties.

The total number of flying hours chargeable to transportation was 483. Landings were made in 51 lakes and the total number of landings was 640.

At various points in this report the adverse weather conditions have been mentioned. The rain gauges at two points in this area registered the highest rainfall ever recorded locally. Inclement weather at the start of the season did not improve during the whole summer. At the air base of Menjobagues it rained on 14 days in June, 13 days in July, 20 days in August, 17 days in September and 4 days in October prior to the conclusion of operations on the 10th of the month.

GEODETIC ASTRONOMY, ISOSTASY AND BASE LINES

Geodetic Astronomy

Six triangulation stations of the Geodetic Survey of Canada were occupied as Laplace stations (longitude and azimuth), namely Ruddell, Red Deer Hill and Pleasant Valley in the province of Saskatchewan, Foxville and Wurtele in the province of Ontario, and Lytton in the province of Quebec.

Ruddell, Red Deer Hill and Pleasant Valley are points in the triangulation net of northern Saskatchewan. At Ruddell, the azimuth of the line Ruddell to Rossall was observed, at Red Deer Hill the azimuth of the line to Gwendoline and at Pleasant Valley the azimuth of the line to Beatty.

Nine Laplace stations have now been observed to control the direction of the geodetic triangulation in Alberta and Saskatchewan. Two or three more are needed in the area between Saskatoon and the international boundary line.

The Laplace stations at Foxville and Wurtele were observed to control the direction of the precise traverse on the Temiskaming and Northern Ontario railway north from Cochrane to Coral Rapids.

The Laplace station at Lytton in the Gatineau triangulation net was established to control the direction of that net. The azimuth of the line, Lytton to Lacroix was observed.

In addition to the longitude and azimuth observations, astronomical latitude was observed at each station.

Deflection of the Vertical.—Astronomic latitude and longitude were observed at eleven stations in the geodetic triangulation net in the Maritime Provinces, namely Five Fingers, N.B.; West Point, Tignish, Irishtown, Tea Hill, Bear Point and Red Point, P.E.I.; Cape Tormentine and Norton, N.B., and Amherst and East Cape, Magdalen islands.

Astronomical observations for longitude and latitude have now been made at over one hundred geodetic triangulation stations. The differences between the astronomic and geodetic values give the deflections of the vertical both in the Meridian and the Prime Vertical.

Manitoba-Ontario Boundary Determinations

A determination of longitude and latitude was made in 1929 at the east end of Island lake on the boundary line between Manitoba and Ontario. According to statute the interprovincial boundary runs northeasterly from this point to a point on the south shore of Hudson bay where the 89th Meridian intersects the shore line.

In order to locate this boundary line a Geodetic Survey party, in July, 1930, determined the point of intersection of these two lines and marked it with a concrete pier. The latitude of this point was also determined and a geodetic computation* was made in order to furnish the engineers engaged by the Manitoba-Ontario Boundary Commission with the azimuth or direction of the line from Island lake to Hudson bay which they required in commencing the demarcation of the boundary.

After establishing the Hudson Bay terminal point, the azimuth of the theoretical connecting line between this terminal and the one at Island lake was computed and a short section of line as shown on the map on page 20 was actually run on the ground.

By means of longitude and latitude determinations, the same Geodetic Survey party also established geodetic control stations at two intermediate points along the boundary line. The topographical features in the vicinity of the stations were surveyed so that they could be used as guides by the aircraft engaged in photographing a strip of terrain along the 280-mile boundary line. Transportation from Winnipeg to the two intermediate points was supplied by

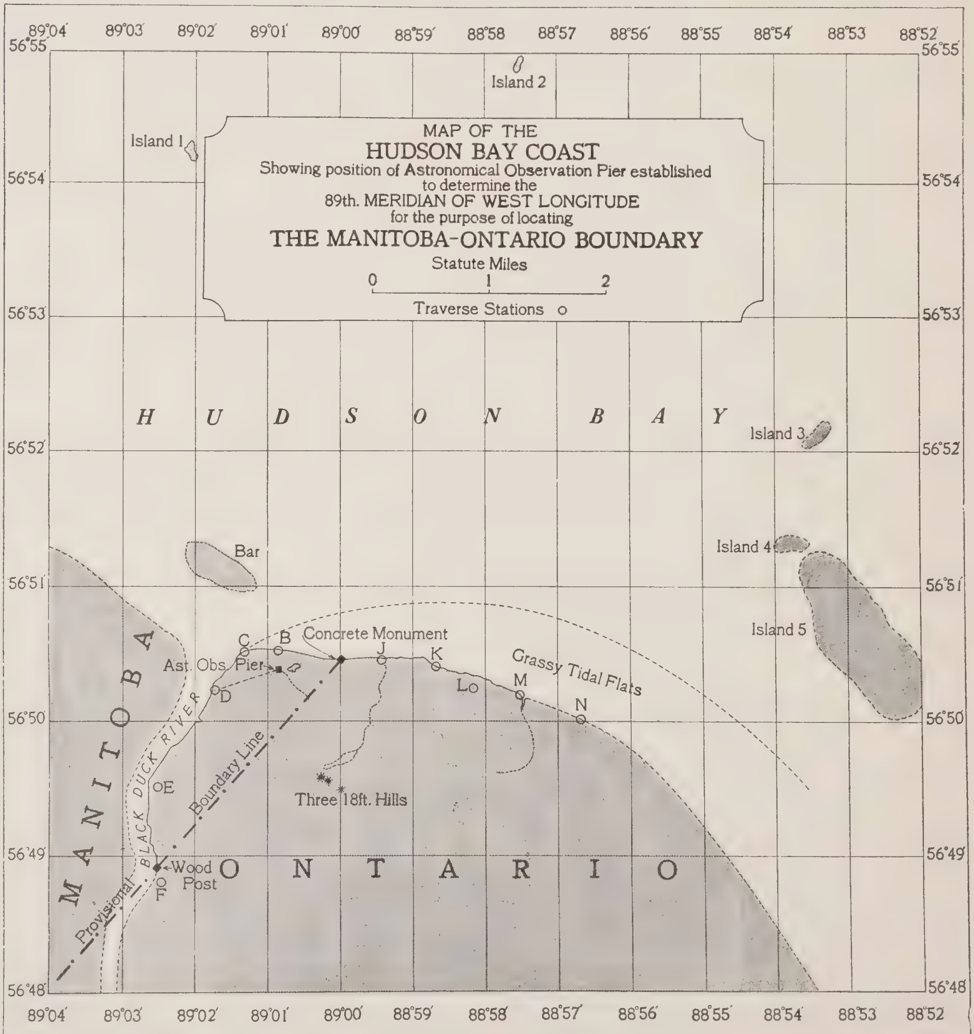
* See page 28, Annual Report of the Director of the Geodetic Survey of Canada, 1928-29.


GEODETIC SURVEY OF CANADA
Noel J. Ogilvie, Director
OBSERVED ASTRONOMICAL POINTS.
To March 31st 1931
Statute Miles
100 0 100 200 300 400 500

the Royal Canadian Air Force, two planes being placed at the disposal of the Geodetic Survey party. Transportation from the point where the Hudson Bay railway crosses the Nelson river to the Hudson Bay terminal of the boundary was provided by means of two twenty-foot canoes with outboard motors. The astronomical outfit consisting of instruments, tents and supplies was shipped by rail to the crossing of Nelson river; here, it was loaded into the canoes and taken down the Nelson to York Factory, and thence along the shore of Hudson bay to the geodetic station. The observations at the 89th Meridian consisted of longitude on four nights and thirty latitude determinations.

The concrete pier marking the point where the 89th Meridian intersects the shore line of Hudson bay is surrounded with a cairn of rocks. It is difficult for navigators of the sea or air on the coast to locate the position of this terminal except by sighting islands Nos. 1 to 5 and the three 18-foot hills marked on the map below. These islands were located by instrumental readings from the traverse stations and are correct in general position but their shore lines are sketched and not surveyed.

At York Factory longitude and latitude determinations were made for the location of a Hydrographic Survey beacon.



Plan No.433WGR Block 543

Isostasy

Work in isostasy has occupied some time of this Division. Templates have been prepared and the topographic corrections to the direction of the plumb line in both the meridian and prime vertical have been deduced for a number of stations. The results of an isostatic investigation as far as Eastern Canada observations are concerned will be published in the near future.

Base Lines

One base line, between the geodetic stations Lytton and Lacroix in the Gatineau Valley triangulation was measured to control the scale of the triangulation in this net. It extends over a very uneven stretch of country so that there were large differences of elevation between posts and a number of broken chain lengths. In order to cross the Le Lievre river it was necessary to use the hundred-metre tape on four different occasions. This tape was carefully standardized by comparisons with the fifty-metre base line invar tapes. Towers, from ten to forty feet high, were built on the various parts of the base to reduce the grades and to cross ravines and swamps.

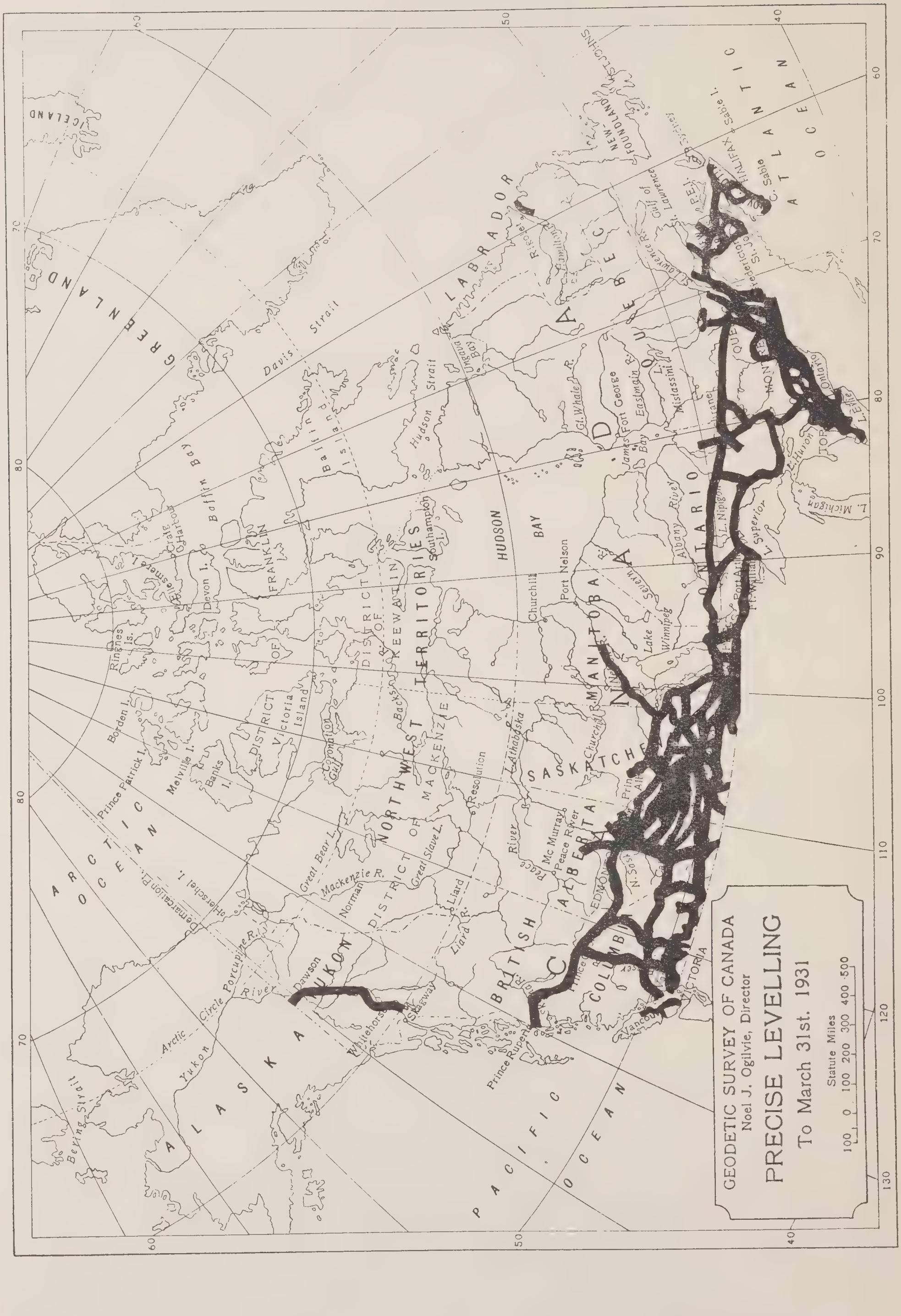
Standards

The three fifty-metre invar base line tapes Nos. 3139, 3140 and 3141 were standardized before and after measuring the Lacroix base line. These tapes have behaved in a most satisfactory manner. This is due to the stability which they have attained through aging, and to the care of the officer in charge of them in the field.

LEVELLING

Levelling operations were carried out in the summer of 1930 in three of the provinces—Ontario, Quebec and British Columbia. In addition to the regular work of extending lines of control levels and establishing standard bench marks, a special party consisting of an engineer and one assistant was engaged in the establishment of fundamental bench marks in southeastern Manitoba and northern and eastern Ontario.

Three-quarters of the season's levelling was composed of what is designated as " Secondary levelling " and one-quarter was " Precise levelling." The routes for secondary levels are selected with the sole object of placing bench marks where they will be of maximum service to engineers and surveyors, whereas in the layout of precise level lines the paramount consideration is the attainment of the highest accuracy for each line and the strengthening of the general level net. To fulfil these respective requirements, it is the general practice for precise levels to follow railway lines and for secondary levels to follow highways and country roads. While certain refinements in field methods used in the precise work are dropped from the secondary levelling procedure, the fact that the comprehensive precise level net permits the secondary lines to be adjusted to the precise datum at frequent intervals precludes the accumulation of systematic errors to any extent that could be harmful. While, as the name implies, the secondary levelling is of a lower grade, nevertheless the difference in the standard of accuracy between the two grades is so slight that it is unappreciable from a practical point of view. Specifically, the points of difference between the secondary and precise methods are as follows: (1) The limit of divergence between forward and backward levelling over a section 1 mile in length may be permitted to reach ·030 foot instead of being held to ·017 foot. (2) When making the rod readings the backsights are always taken first instead of the


GEODETIC SURVEY OF CANADA
Noel J. Ogilvie, Director
PRECISE LEVELLING
To March 31st. 1931
Statute Miles
100 0 100 200 300 400 500

foresights and backsights being read alternately. (3) Only the centre cross-wire in the levelling instrument is used instead of three wires being read and the mean of the readings used in the computations. It will be observed that the tendency of all the points of distinction noted is to accelerate the progress of the work; this tendency is usually counteracted more or less completely, however, by the fact that the highway routes are not usually as well graded or otherwise suitable for rapid progress as are the railways.

The above explanation is made in order to dispel any idea that a lower grade of work is being undertaken now than formerly; it should rather be regarded as a case of the foundation of the structure being largely completed, permitting concentration upon the superstructure.

An innovation in the levelling procedure for the current year was the design and manufacture of bench mark tablets with the wording in the French language, for use in the French-speaking portions of the country. These tablets bear the legend—" Service Géodésique du Canada, Ottawa, B.M."

Levelling in the Province of Ontario

Continuation of the 1929 season's work in the Muskoka district and adjoining counties occupied the Ontario secondary levelling party throughout the summer, the controlled areas being extended systematically in a general easterly and southerly direction. Picking up the discontinued line near the village of Rosseau, the main Parry Sound-Bracebridge road was followed to its junction with the Toronto-North Bay highway and the latter used to reach Orillia. From this point the levels continued east through Norland and Kinmount and thence northerly to Minden and Dorset, a branch to Haliburton being included. Dorset was also reached by a line starting at Bracebridge and circling the lake of Bays to close at Huntsville. Resuming at Kinmount the party worked along the Bobcaygeon road to the village of Bobcaygeon, thence to Lindsay and thence along the Brampton-Peterboro highway (No. 7) as far west as Sunderland. From this point levels were extended northerly to Beaverton and Talbot and southerly through Port Perry and Blackstock to close at Bowmanville, on lake Ontario. During the season's operations connections were made with the precise level system at seven points.

Levelling in the Province of Quebec

The general plan followed in the secondary levelling in the province of Quebec was to run a series of approximately parallel lines of levels from the north shore of the St. Lawrence river in a northwesterly direction as far as the condition of the roads permitted this to be done economically. Lines were run from Louiseville to St. Alexis des Monts, from Berthierville to St. Michel des Saints and two lines from Joliette to Ste. Emelie de l'Energie—via St. Felix de Valois and via Ste. Ambroise. A line at right angles to the above was extended along provincial highway No. 41 from Berthierville to Lachute, which will form a base for additional inland country lines in the future.

Shortly after the party went into the field a request was received from the United States Geological Survey for levelling control at the international boundary at Lac Frontiere, P.Q., for use in connection with topographical mapping in northern Maine. As the work asked for would in any case have been on the program for some future year, it was decided to interrupt the regular operations of the party for a few weeks in order to comply with the request; accordingly a line of levels was run from Monk, on the Quebec-Edmundston line of the Cana-

dian National railway to Lac Frontiere, via provincial highway No. 24, Monk being the most convenient point on the precise level system. Obviously it will be of advantage to have the topographical maps on the United States side of the Quebec-Maine border on the same datum as those on the Canadian side.

During the course of the party's regular levelling operations, fundamental bench marks were established at Berthierville, Louiseville, Joliette and St. Jerome.

Levelling in the Province of British Columbia

This party's time from the beginning of the season until the latter part of August was occupied in completing the precise level lines on Vancouver island which had been begun in 1929. Starting from Nanaimo, the Esquimalt and Nanaimo railway was followed to Port Alberni and also to Courtenay; from the latter point the levels were continued along the Island highway northward along the coast to the village of Campbell River and thence inland to Forbes Landing and Elk falls on the Campbell river.

Another request having been received from the United States Geological Survey, this time for levelling control at the international boundary south of Nelson, B.C., and also from the Dominion Water Power and Hydrometric Bureau, Department of the Interior, for levelling in the same vicinity, the party was transferred to this district on the completion of the operations on the Island and a line of secondary levels was run along the Canadian Pacific railway from Castlegar to Trail, thence by road to the international boundary at Waneta and thence by road along the right bank of the Pend d'Oreille river to Nelway, the point at which the Nelson-Spokane highway crosses the international boundary. The bench marks established along this line are proving of immediate use to the Dominion Department of Public Works and to certain power interests.

Preceding and during the regular levelling operations of this party, five Fundamental bench marks were constructed and tied in, at Vancouver and New Westminster on the mainland and at Nanaimo, Port Alberni and Courtenay on Vancouver island. Connections with Tidal Survey bench marks were made at Nanaimo, Port Alberni and Comox.

Special Work

A special party consisting of an engineer and one assistant established fundamental bench marks in certain cities and towns in southeastern Manitoba and northern and eastern Ontario, this being a continuation of the program carried out in the prairies in 1928 and 1929.* The monuments—fifteen in all—were established at the following places: *In Manitoba*—Winnipeg, Emerson and Sprague; *in Ontario*—Kenora, Sioux Lookout, Rainy River, Fort Frances, Fort William, Port Arthur, Blind River, Webbwood, Sudbury, Haileybury, Algonquin Park Station, and Renfrew.

The actual construction, in accordance with previous practice, was carried out in each place by contract or by day labour, employed locally. Additional standard bench marks were established in several of the places at which fundamental bench marks were constructed, these for the most part being in public buildings of a permanent nature erected subsequent to the original levelling.

The work of attaching bronze plates, upon which the elevation above mean sea level has been engraved, to fundamental bench marks constructed in earlier years was carried on as opportunity offered, some 41 of these elevation plates being set in position during the year. Of this number 33 were placed by the special party, and the remainder by the regular levelling parties.

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*A full description of the fundamental bench marks and the principles guiding their location will be found in the Report of the Director of the Geodetic Survey of Canada, 1926.

Detailed Statement of Mileage of Levelling Run in 1930

Precise Levelling

—	On railway	Off railway	Total
	miles	miles	miles
Connection at Berthierville, P.Q.	....	5·9	5·9
Connection at Louiseville, P.Q.	....	2·6	2·6
Lanoraie to Joliette, P.Q.	7·5	2·5	10·0
Nanaimo to Port Alberni, B.C.	72·2	3·1	75·3
Parksville to Campbell River, B.C.	44·5	50·8	95·3
	124·2	64·9	189·1

Secondary Levelling

	Miles
Louiseville to St. Alexis des Monts, P.Q.	24·3
Berthierville to St. Michel des Saints, P.Q.	77·3
Joliette to Lachute, P.Q.	61·3
Ste. Emelie de l'Energie to Joliette, P.Q., via St. Felix	28·1
Ste. Emelie de l'Energie to Joliette, P.Q., via St. Ambroise	40·3
Lafontaine to Lac Frontiere, P.Q.	41·1
Rosseau to Orillia, Ont.	65·3
Bracebridge to Huntsville, Ont.	57·6
Orillia to Dorset, Ont.	108·1
Kinmount to Sunderland, Ont.	71·5
Talbot to Bowmanville, Ont.	63·7
Castlegar to Nelway, B.C.	41·8
	680·4

Summary by Provinces for 1930

—	Miles	B. Ms.
Precise Levelling—		
Quebec	18	17
Ontario	....	20
Manitoba	....	7
British Columbia	171	74
	189	118
Secondary Levelling—		
Quebec	272	138
Ontario	366	227
British Columbia	42	23
	680	388

The total mileage of precise and secondary levelling in each of the provinces at the end of the fiscal year is as follows:—

—	Precise Levelling			Secondary Levelling		
	Prior to 1930	1930	Total	Prior to 1930	1930	Total
Nova Scotia	729	....	729	....	....	....
New Brunswick	1,096	....	1,096	....	....	....
Quebec	3,359	18	3,377	368	272	640
Ontario	5,842	....	5,842	629	366	995
Manitoba	2,263	....	2,263	368	....	368
Saskatchewan	4,113	....	4,113	5,098	....	5,098
Alberta	2,866	....	2,866	3,795	....	3,795
British Columbia	3,453	171	3,624	....	42	42
Yukon	458	....	458	....	....	....
Minnesota	89	....	89	....	....	....
Vermont	6	....	6	....	....	....
	24,274	189	24,463	10,258	680	10,938

The mileage of *precise* levelling along each of the railways is as follows:—

Railway	Miles
Canadian National	11,691
*Canadian Pacific	7,893
Northern Alberta	452
Temiskaming and Northern Ontario	385
Pacific Great Eastern	357
Algoma Central	319
Great Northern	230
Esquimalt and Nanaimo	189
Quebec Central	149
Dominion Atlantic	146
White Pass and Yukon	91
Temiscouata	82
Nipissing Central	59
New York Central	55
Pere Marquette	55
Maine Central	36
Roberval and Saguenay	31
Napierville Junction	28
British Columbia Electric	28
Quebec Railway, Light and Power Co	25
London and Port Stanley	24
Alma and Jonquiere	16
Maritime Coal, Railway and Power Co	12
Michigan Central	3
Highways and cross-country	2,107
	24,463

*Including the line formerly known as the former Kettle Valley Ry.

GEODETIC RESEARCH

The chief problem which has occupied the attention of this division is that of transferring geodetic data from one spheroid to another.

In past years, this problem has been studied by geodesists of various countries, and since 1924 the solution of the problem has become imperative as a result of the decision of the International Union of Geodesy and Geophysics to adopt the same spheroid of reference for all countries of the world. As the spheroid adopted is, both in size and shape, different from any other spheroid at present in use, the problem now under consideration is one which confronts all countries that are carrying on geodetic surveys.

In attempting to solve this problem, it has always been kept in mind that on account of the vast number of geodetic points that are to be changed from one spheroid to another, the final process of making the transformation must be as simple as possible.

The stage has been reached where it can safely be said that a differential formula for the change in latitude has been arrived at. Some progress has been made in a formula for the change in longitude.

The theory developed by this division for the solution of long geodetic lines has had a practical application in connection with the Manitoba-Ontario boundary.

TRIANGULATION ADJUSTMENT AND PRECISIONS

The functions of this Division include the reduction of triangulation and precise traverse data to geographic positions; the reduction of zenith distances to trigonometric elevations; the maintenance of geodetic statistics; the preparation of information for Government departments and for the surveying and engineer-

ing public; the preparation and issuance of technical publications containing the geographic positions (latitude and longitude) of the stations established; the lengths and azimuths of the lines joining contiguous stations; a discussion of the accuracy of the work, and a description of the methods employed; and related matter.

The geographic positions of triangulation stations are obtained through an indirect method, that is, the observed quantities are not usually the geographic positions. In large areas, nets of triangulation of approximately 250 miles in length are used as units. In general, linear measurements of one or more lines are made in each unit to control the scale; direct observations for latitude, longitude and azimuth are made at a few selected stations to control the direction or azimuth; and finally the angles at all the stations are observed in order to incorporate these values throughout the net. Errors of degree exist in every phase of the determination of any measured quantity but in comparison with the angular measurements those of the scale and azimuth controls are relatively much more accurate and in practice are accepted as without error. The problem then of adjustment of the observed values of the angles is to remove discrepancies in the local conditions and to maintain collectively the values of the controls. This is achieved through application of the laws of probability. From the adjusted angles the length of all the lines may be calculated and these combined with an initial latitude and longitude of a station together with an azimuth line permit the calculations of the geographic positions throughout the triangulation net.

At the same time as the observations for horizontal angles between triangulation stations are made, vertical angles or zenith distances are obtained which allow the differences of elevations of stations in pairs to be calculated. Controls are established through connections with the precise level system and a rigorous adjustment will then give consistent results over the various routes. Owing to the variableness of refraction the accuracy of the results is at times of secondary order but the application lies in that results sufficiently accurate for topographic control in outlying districts are easily obtained in most cases.

Adjustments of the various triangulation nets have been made as the field work progressed. In this way consistent results over minor areas have been supplied and are available to the public immediately after the completion of the field work.

Consistent results over major areas are involved because of the closures of loops of triangulation. These loops are in general too large to be treated as a unit and the proportionment of the closure discrepancies throughout the individual nets is an extensive operation. The methods recently devised by the United States Coast and Geodetic Survey are instructive but at present inapplicable to Canadian practice owing to the fact that nearly all of the proposed triangulation of first order must be completed before they can be applied.

Publication of the triangulation results easterly from Montreal has been carried on. The results will be given out in six publications under the following numbers and titles covering in general the areas specified:—

No. 30. Triangulation in New Brunswick and Nova Scotia.
Areas—bay of Fundy; thence southerly to Halifax; thence southwesterly to Liverpool, N.S. and northerly.

No. 31. Triangulation in Quebec and New Brunswick.
Areas—Chaleur bay and Matapedia valley.

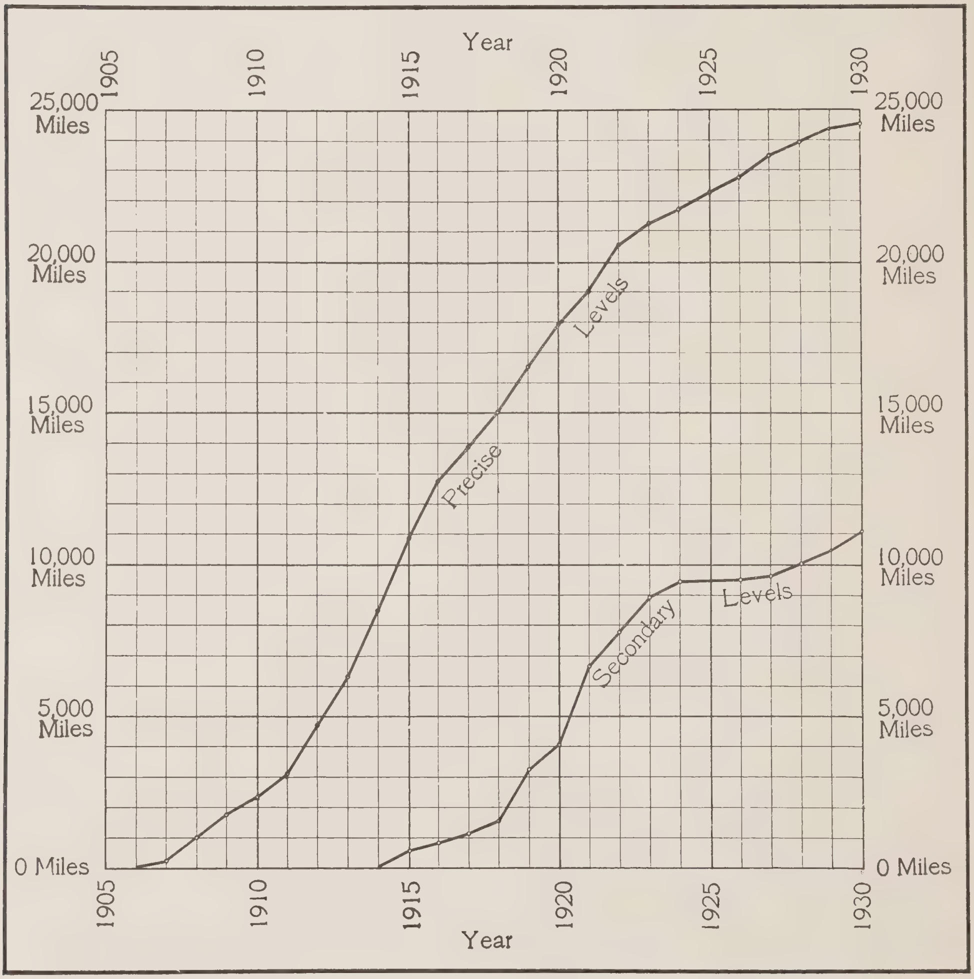
No. 32. Triangulation in New Brunswick and Prince Edward Island.
Areas—Eastern and western portions of New Brunswick; Northumberland straits.

No. 33. Triangulation in Eastern Nova Scotia Magdalen Islands and Southwestern Newfoundland.
Areas—Nova Scotia easterly from Truro; Magdalen Islands; southwest coast of Newfoundland.

No. 34. Triangulation in Quebec.
Area—Easterly from Montreal to Anticosti island.

No. 35. Triangulation closure in the Maritime Provinces—Latitude and Longitude Nomograms.

Of the above all except No. 34 are available for distribution to the public.



Precise and Secondary Levelling, 1930.

ADJUSTED ELEVATIONS

A very important change was introduced in the adjustments of the year 1930 so as to improve the foundation on which the level net of Canada is based.

It will be seen by referring to Publication No. 28, in which appears a full description of the methods of the adjustment of the precise level net, that the net as adjusted in 1928 was based on tidal stations on the Atlantic and Pacific coasts and on an elevation for Rouses Point, temporarily accepted as fixed by the

United States and Canada at a conference held in 1926. More recently, however, it was learned that after a considerable amount of re-levelling and new levelling in the East, the Coast and Geodetic Survey of the United States no longer adhered to the formerly accepted elevation of Rouses Point. It then became advisable for the Geodetic Survey of Canada to discard Rouses Point as a fixed point and place the precise level net on mean sea level as fixed by Canadian tidal stations only.

A new adjustment was then carried out omitting the equation in which Rouses Point appeared as a fixed point. There remained 93 equations in this adjustment which has been called Adjustment "A". The result of the new adjustment was a considerable change in elevation found for Rouses Point and all points in its neighbourhood. The new elevation of Rouses Point was 108·056 feet compared with the old accepted elevation of 108·150 feet. Changes in elevations of other points in the net decrease with the distance from Rouses Point to zero at the coasts.

A second adjustment, Adjustment "B," was added to the above. This contains six new equations added to the former ninety-three. Numbers 94 and 95 are formed from new circuits made by lines 130 and 131. Line 130 runs from Ashcroft, B.C., to Clinton, B.C., and line 131 from a tidal station on the Pacific at Squamish through Clinton to Prince George, B.C., on line 91. These break up the large circuit—Vancouver-Ashcroft-Kamloops-Red Pass Jct.-Prince George-Prince Rupert, B.C. The next three new circuits which give equations 96, 97 and 98 are found by lines 126 and 127 which join the central point Canora, Sask., with Yorkton, Sask., Dana, Sask., Swan River, Man., and Dauphin, Man. These circuits lie in the provinces of Manitoba and Saskatchewan. Circuit No. 99 is formed by a line running from Swastika, Ont., on line 97 to Taschereau, Que., on line 100.

In these two adjustments no orthometric correction is put on the lake levels.

MECHANICAL DESIGN DIVISION

An adjustable electric signal lamp was designed and tested, and a precise traverse electric signal was outlined. Progress was made in the construction of an instrument for an aerial method of triangulation. An instrument was designed for a method of determining the latitude, departure and elevation of objects shown in terrestrial photographs taken from mountain tops. A new system of colours for the graduations on precise level rods was tested. A chronograph of a new and compact type for field work was designed. Originals for illustrations and coloured maps were prepared. Models were engraved for electrotyping station tablets. Repairs in wooden parts of instruments were made. Instruments and equipment were listed and stored.

LOCALITY OF FIELD OPERATIONS OF THE GEODETIC SURVEY OF CANADA DURING THE FISCAL YEAR ENDED MARCH 31, 1930

TRIANGULATION

Southern British Columbia	Primary Triangulation—reconnaissance, angular measurements, station preparation.
Saskatchewan	Primary Triangulation—aerial reconnaissance, angular measurements, station preparation and tower building.
Northern Ontario	Primary Triangulation—aerial reconnaissance, angular measurements, station preparation, tower building. Precise traverse.
Northern Quebec	Primary Triangulation—aerial reconnaissance, angular measurements, station preparation and tower building.

GEODETIC ASTRONOMY, ISOSTASY AND BASE LINES

Saskatchewan, Ontario and Quebec	Laplace Stations.
New Brunswick, Prince Edward Island and Magdalen Islands	Isostasy Investigation.
Ontario-Manitoba Boundary and Hudson	Astronomical Points.
Quebec	Base Line Measurements.

LEVELLING

British Columbia	Precise Levelling.
Manitoba	Construction of fundamental bench marks.
Ontario	Construction of fundamental bench marks. Secondary levelling.
Quebec	Secondary levelling.

PUBLICATIONS

Seven publications of the Geodetic Survey of Canada were printed and distributed. A number of other publications were prepared for the printer. A number of articles touching the Geodetic Survey of Canada were summarized for the press. The mailing list used for the distribution of Geodetic Survey publications was revised. A list of the publications of the Geodetic Survey of Canada follows:—

PUBLICATIONS OF THE GEODETIC SURVEY OF CANADA

Publication No.

2—Adjustment of Geodetic Triangulation in the Provinces of Ontario and Quebec, 10 cents.

3—Determination of the Lengths of Invar Base Line Tapes from Standard Nickel Bar No. 10239, 10 cents.

5—Field instructions to Geodetic Engineers in charge of Direction Measurement on Primary Triangulation, $1.00.

Instructions to Lightkeepers; Use of Electric Signal Lamps being an Appendix (No. 4) to Publication No. 5, 10 cents.

7—Geodetic Position Evaluation, 10 cents.

8—Field Instructions for Precise Levelling, 10 cents.

PUBLICATIONS OF THE GEODETIC SURVEY OF CANADA—*Concluded*

Publication No.

10—Instructions for Building Triangulation Towers, 10 cents.

11—Geodesy, 50 cents.

12—Mathematical Statistics of the Geodetic Survey of London, Ont. (Distributed at London, Ont.).

14—Levelling, Co-ordination of Elevations of Bench Marks in the City of Calgary, Alberta, 10 cents.

15—Levelling. Bench Marks Established along Meridians, Base Lines and Township Outlines in Saskatchewan, 10 cents.

16—Levelling. Precise Levelling in Nova Scotia, New Brunswick and Prince Edward Island, 10 cents.

17—Levelling. Precise Levelling in Quebec South of St. Lawrence River, 10 cents.

18—Levelling. Precise Levelling in Quebec North of St. Lawrence River, 10 cents

19—Levelling. Precise Levelling in Ontario South of Parry Sound, 10 cents.

20—Levelling. Precise Levelling in Ontario North of Parry Sound, 10 cents.

21—Levelling. Precise Levelling in Manitoba, 10 cents.

22—Levelling. Precise Levelling in Saskatchewan, 10 cents.

23—Levelling. Precise Levelling in Alberta, 10 cents.

24—Levelling. Precise Levelling in British Columbia, 10 cents.

25—The Conversion of Latitudes and Departures of a Traverse to Geodetic Differences of Latitude and Longitude, 25 cents.

26—The Simultaneous Adjustment of Precise Traverses and Triangulation Nets, 25 cents.

27—The Differential Adjustment of Observations, 25 cents.

28—Adjustment of Precise Level Net of Canada, 1928, 10 cents.

30—Triangulation in New Brunswick and Nova Scotia, 50 cents.

35—Triangulation Closure in the Maritime Provinces, 50 cents.

36—Deflection of the Plumb Line in Canada, 25 cents.

Report of the Operations of the Geodetic Survey of Canada, April, 1912, to March, 1922, prepared by the Director for the First General Assembly of the International Geodetic and Geophysical Union held at Rome, 1922. (Bound with the Reports of the Section of Geodesy of the International Geodetic and Geophysical Union, 1922), 10 cents.

Report of the Operations of the Geodetic Survey of Canada, April, 1922, to March, 1924, prepared by the Director for the Second General Assembly of the International Geodetic and Geophysical Union held at Madrid, 1924, 10 cents.

Report of the Operations of the Geodetic Survey of Canada, April, 1924, to December, 1926, prepared by the Director for the Third General Assembly of the International Geodetic and Geophysical Union held at Prague, 1927, 10 cents.

37—Geodetic Operations in Canada.—January 1, 1927, to December 31, 1929. Reports of the Section of Geodesy—The International Geodetic and Geophysical Union, Fourth General Conference, Stockholm, 1930, 10 cents.

Annual Report of the Superintendent of the Geodetic Survey of Canada for the fiscal year ending March 31, 1918, 10 cents. The same for the year 1922, 10 cents.

Annual Reports of the Director of the Geodetic Survey of Canada for the fiscal years, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1930, 1931; each 10 cents.

Where name and number (or year) are omitted, the publication is not available for distribution.

Copies of the above publications may be obtained by applying to the Director of the Geodetic Survey of Canada, Department of the Interior, Ottawa.

Reqn. 5420